Using dynamically downscaled climate model outputs to inform projections of extreme precipitation events

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Overview

- Stormwater managers require future scenarios of sub-daily extreme precipitation events to inform infrastructure investments
- However, most scenario planning tools do not provide projections for sub-daily extreme events
- An evaluation of future changes in extreme precipitation from three general circulation models (MIROC5, MRI-CGCM3, and GFDL-ESM2G) did not indicate consistent differences in the rate of change between sub-daily and daily precipitation extremes
- We used regional climate model (RCM) outputs to evaluate whether these higher-resolution models project consistent patterns of change for sub-daily vs daily precipitation extremes

Methods (1)

- We used 36-km resolution Weather Research and Forecasting (WRF) model runs driven by CESM (NCAR/DOE) and GFDL-CM3 (NOAA) under RCP 8.5.
- We extracted 3-hourly WRF model results from 6x6 boxes of WRF grid cells representing each of the 9 climate regions in the United States, as defined by the National Climatic Data Center (**Figure 1**)
- For this pilot study, we compared precipitation projections from a 10-year baseline period (1995-2005) to a 10-year future period (2045-2055)

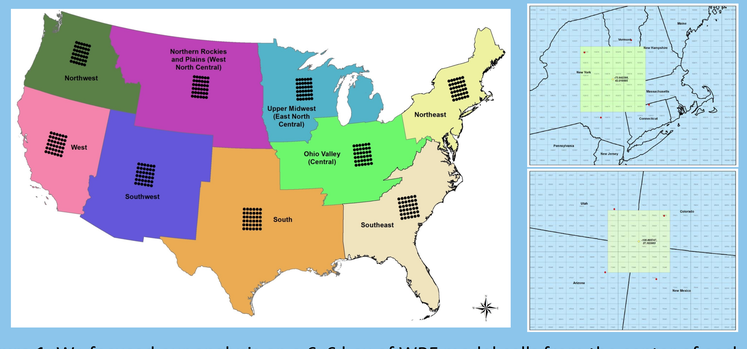


Figure 1. We focused our analysis on a 6x6 box of WRF model cells from the center of each climate region of the contiguous United States

- We extracted 3-hr and 24-hr annual maximum precipitation time series from each RCM grid box in each region (**Figure 2**)

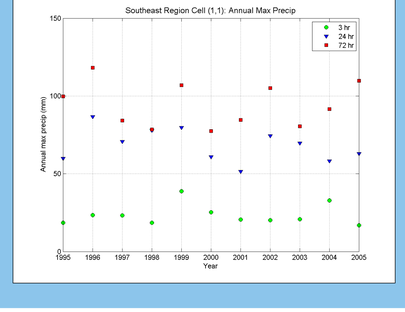
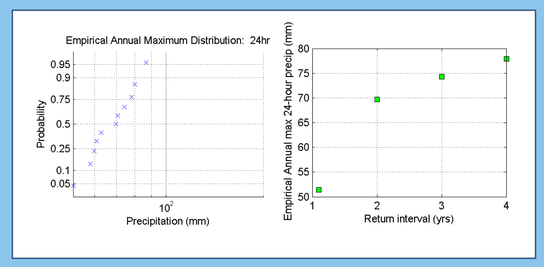


Figure 2. Example of annual maximum time series from a single grid box in the southeast region

Methods (2)

- We calculated the empirical 1.1-year, 2-year, 3-year, and 4-year return interval (RI) events for each duration event and each grid box
- We compared the future and baseline projections for each duration event (3-hr and 24-hr) and for each return interval, for every grid box in each region (Figure 3)

Figure 3. Example return interval calculation from a single grid cell



- We summarized the results from all 36 WRF model cells in each region to evaluate trends

Results (1)

WRF model outputs project an increase in the magnitude of 3-hr and 24-hr precipitation extremes for many regions of the US, particularly for the southeast and northwest (**Figures 4-5**)

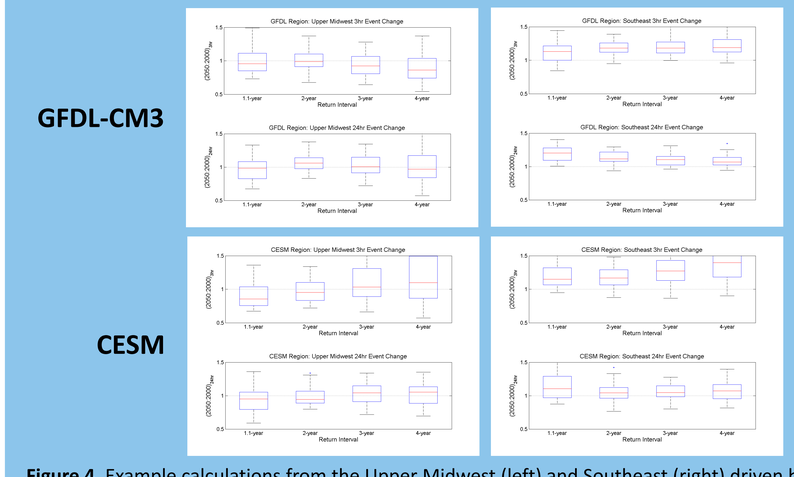


Figure 4. Example calculations from the Upper Midwest (left) and Southeast (right) driven by GFDL and CESM. Box and whisker plots show all 36 change ratios for 3-hr and 24-hr events

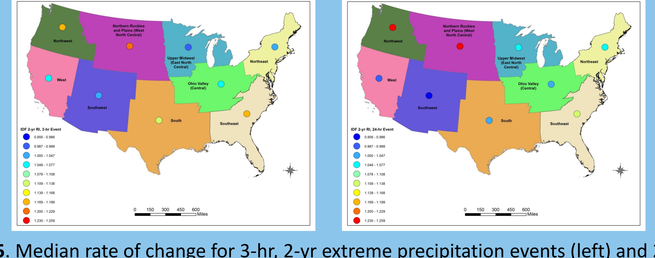


Figure 5. Median rate of change for 3-hr, 2-yr extreme precipitation events (left) and 24-hr, 2-yr extreme precipitation events (right) for each region. Results from GFDL-CM3

Results (2)

- **Figures 6-7** show the ratios between rates of change for 3-hr and 24-hr precipitation extremes between 2000 and 2050
- In general, we did not see a consistent trend in the relative rate of change of shorter vs longer-duration events

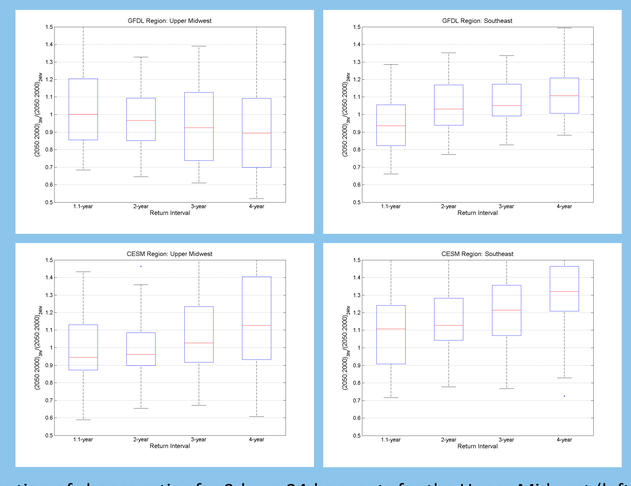


Figure 6. Distribution of change ratios for 3-hr vs 24-hr events for the Upper Midwest (left) and the Southeast (right) driven by GFDL-CM3 and CESM. Ratios greater (less than) 1 suggest that RCM modeled 3-hr events change more (less) than 24-hr events

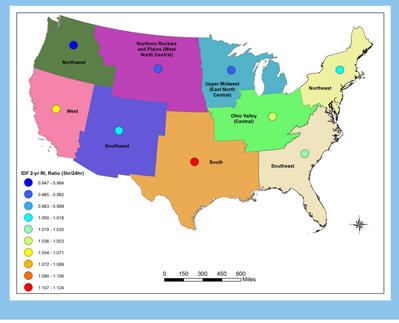


Figure 7. Median change ratio for 3-hr, 2-yr extreme precipitation vs 24-hr, 2-yr extreme precipitation events for each NCDC region in the contiguous United States. Results from GFDL-CM3

Summary

- 36-km resolution RCMs suggest increases in both daily and sub-daily precipitation extremes by 2050, for many regions of the contiguous United States
- Based on this preliminary analysis, we do not see consistent differences in the rate of change of short-duration vs longer-duration extreme precipitation events
- Future work could replicate this method using higher-resolution RCMs that might better resolve convective and cloud processes, and/or expand the analysis to the entire nation

Acknowledgments

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